Mud changes the performance of three rope grabs

Roger Mortimer
David Angel

Various devices are used to secure rope during rescue. These have been tested under somewhat idealized conditions which are good for being able to compare devices but may not always reflect how they may be used in the field. We compared gripping of 8mm Prusiks, the Rescucender, and the MPD under dry and muddy conditions.

A standard mud was created using EM-215 Terracotta clay (Laguna Clays, City of Industry, CA) which was allowed to dry, was broken into dust, then rehydrated to bootsucking consistency (12 pounds of clay dust with 1750 ml tap water). Rope was 1988 PMI static line for the Prusik and Rescucender tests. We used new CMC static for the MPDs. Prusiks were made from new 8mm CMC Prusik cord and used only once. The Rescucender was a lightly used piece in good condition which was cleaned and rinsed prior to each pull. We used two MPDs from CMC stock, one for wet pulls and one for dry pulls. The pre-tied pieces of rope were pre-coated with mud the night before then kept in a garbage bag for the Prusik and Rescucender tests. The Prusik tests used the muddy ropes in sequence out of the bag. Prior to the Rescucender tests the next set of muddy ropes were spritzed with water because of notable drying. For the MPD tests the ropes were muddied immediately prior to pulling. For each test we pulled 5 dry samples and 5 muddy samples, alternating conditions. The CMC rope was fresh off of a spool. The PMI was a retired rope from a rescue team with only minimal visible wear but quite stiff. Five feet was cut from each end of the PMI then the resultant rope cut into 5.5 foot pieces and labeled sequentially. Odd numbered pieces were pulled dry and even numbered pieces were pulled muddy.

Mud changed the performance of each rope grab but in different ways. Mud decreased the maximum grab of Prusiks from a mean of 2945 to 2141 lbf ($p=0.0484$). The peak force in the dry group was consistent but the peak force in the muddy group increased from 1428 to 2677 lbf over time, most likely from drying. Peak force in the Rescucender was higher in the muddy group, 1528 to 2543 lbf ($P=0.0005$). Peak force was also higher in the muddy group for the MPD, 1329 to 2179 lbf ($p<0.0001$). Prusiks and the Rescucender pulls led to failure of the rope each time. The MPD slowly slipped in both conditions without any visible or palpable damage to the rope.

Introduction

Gear is not always deployed in ideal conditions. In cave rescue especially but also in other domains of wilderness rope rescue, ropes may get muddy. Mud may affect how rope and devices behave. We tested 3 devices, 8 mm Prusiks, the Rescucender, and the MPD in dry and muddy conditions.

Methods

After discussing the question with a caver and potter we created a mud as close as possible to cave mud. We did not use real cave mud for conservation and replicability reasons. We used EM-215 Terracotta clay (Laguna Clays, City of Industry, CA) which was allowed to dry in the sun then broken into dust with a hammer and rolling pin. This was then rehydrated with tap water to a boot sucking consistency (12 pounds of clay dust with 1750 ml water).

Testing was done at CMC Industries in Goleta, CA using a hydraulic ram. Sampling was 200 times per second. Statistics were done on maximum force.

In the first series of tests we looked at Prusiks on dry versus muddy rope. The rope was retired 1988 PMI static line (probably pit rope). In a single test pulled it failed at 5404 lbf. The ends were cut off of a 180 foot length then 5.5 foot lengths were cut. Pieces were numbered sequentially. Odd numbered lengths were pulled dry and even numbered pieces were pulled muddy. The muddy ropes had been coated in mud the night before then stored in a garbage bag. The Prusiks were from new CMC 8 mm Prusik cord fresh off of a spool. We went in sequential order, alternating dry and muddy ropes. Each rope/Prusik set was pulled to failure.

In the second series using the Rescucender we used a spritzer to rehydrate the muddy ropes as they were visibly drying. The same lightly used Rescucender was used for each test. It was washed in tap water prior to each pull.

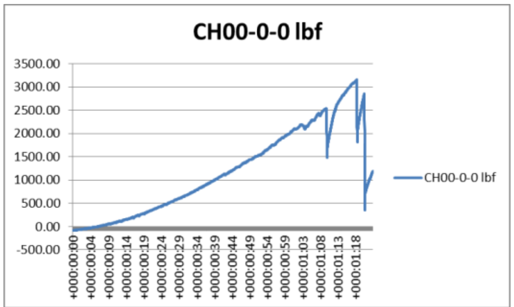
For the third series we used fresh CMC 11 mm rope fresh off of a spool. Five pieces were pulled on a clean MPD and 5 pieces were pulled muddy through a second MPD. The MPD was not cleaned between uses. For the muddy pulls the ropes were pulled three times through a hand with a fresh sample of mud to ensure thorough covering.

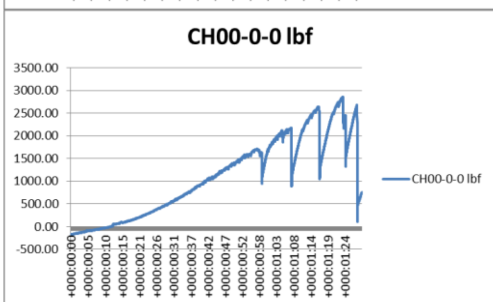
Comparisons were done with a T-test with a two tailed alpha of 0.05.

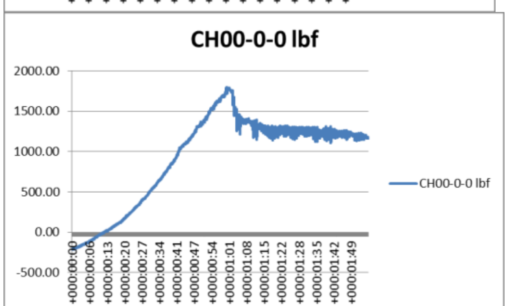
Results

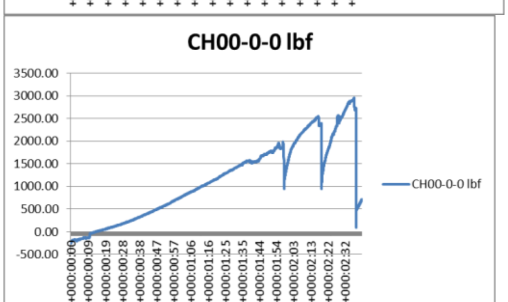
In the first series mud decreased the gripping strength of Prusiks from 2945 to 2141 lbf ($p=0.0484$). The peak force prior to failure was consistent in the dry group but in the muddy group started low (1428 lbf) but increased with time (2677 lbf) as the ropes dried. In the dry group, 4 failed catastrophically while one simply slid. In the muddy group, two failed catastrophically while 3 slid. Clutching behavior was a precursor to failure.

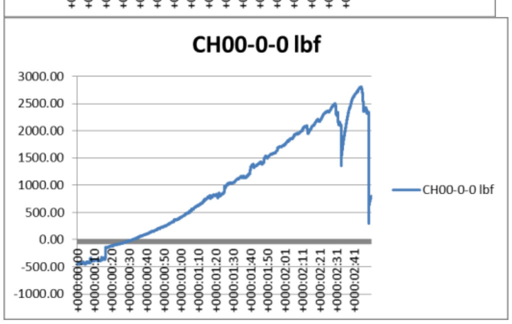
Dry


CH00-0-0 lbf
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-500.00
CH00-0-0 lbf

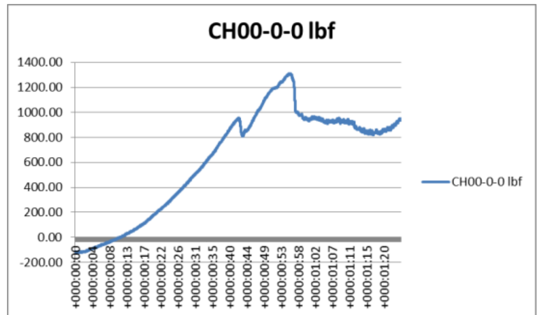

CH00-0-0 lbf
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-500.00
CH00-0-0 lbf

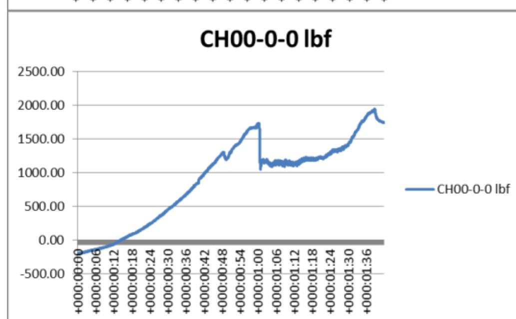

CH00-0-0 lbf
2000.00
1500.00
1000.00
500.00
0.00
-500.00
CH00-0-0 lbf

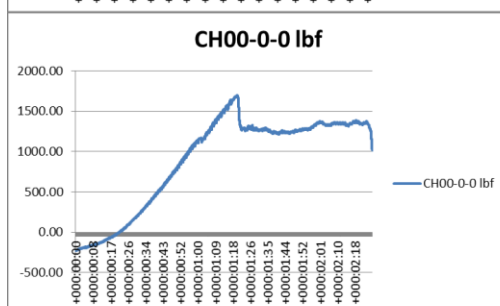

CH00-0-0 lbf
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-500.00
CH00-0-0 lbf

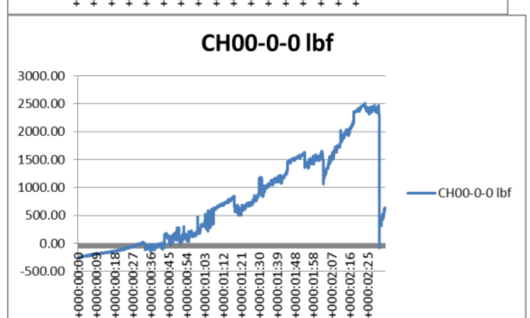

CH00-0-0 lbf
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-500.00
-1000.00
CH00-0-0 lbf

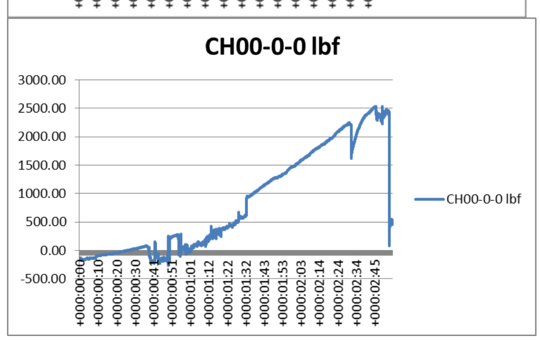
Wet


CH00-0-0 lbf
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
-200.00
CH00-0-0 lbf


CH00-0-0 lbf
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-500.00
CH00-0-0 lbf

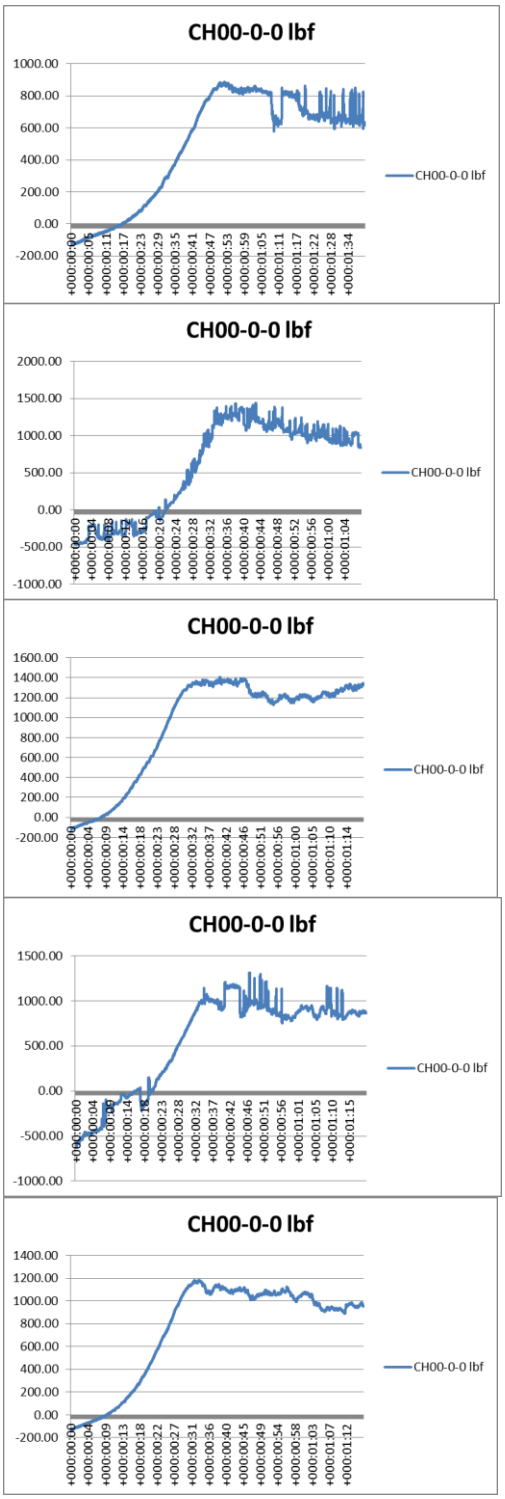

CH00-0-0 lbf
2000.00
1500.00
1000.00
500.00
0.00
-500.00
CH00-0-0 lbf


CH00-0-0 lbf
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-500.00
CH00-0-0 lbf

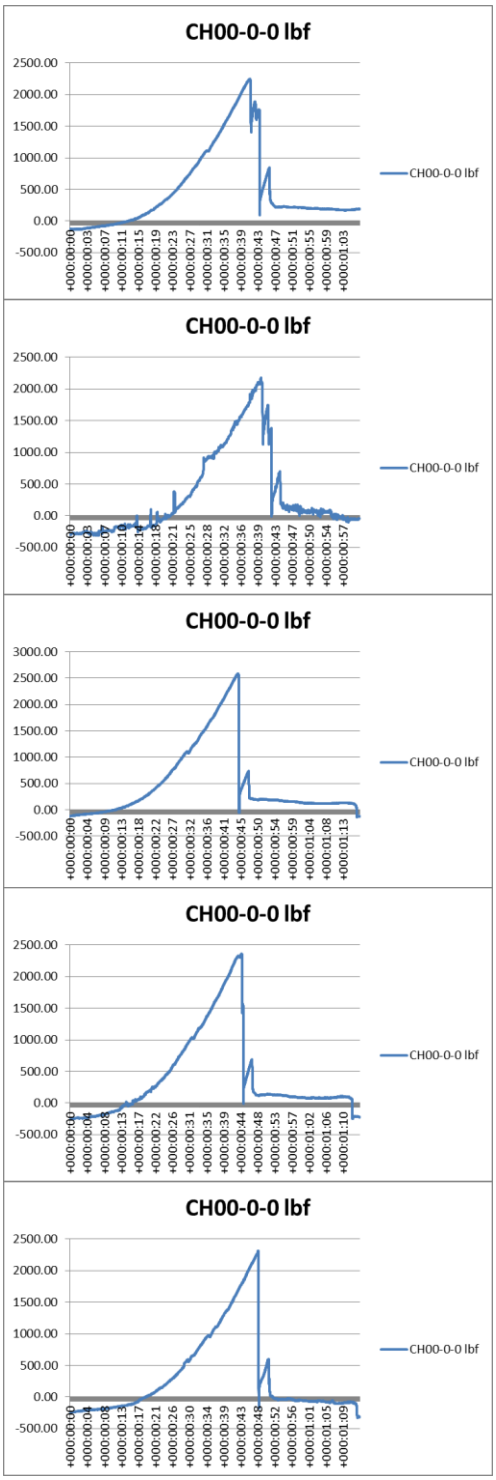

CH00-0-0 lbf
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-500.00
CH00-0-0 lbf

In the Rescucender series peak force in the Rescucender was higher in the muddy group, 1528 to 2543 lbf (P=0.0005). However in the dry rope the Rescucender consistently slid after hitting its peak force while it stripped the sheath after developing a higher peak force.

Dry



Muddy



In our third comparison we looked at performance of the MPD on dry and muddy ropes. In this trial the mud was consistently fresh. Mean peak force was higher in the muddy group at 2179 lbf compared to 1329 lbf with the dry rope ($P<0.0001$). The devices slipped as designed but at different forces. Groups were much more consistent. No ropes failed. There were no visible or palpable changes to the rope in either group.

Discussion

Mud does change the performance of rope grabs but not in a consistent way. Prusiks are more likely to slip in muddy conditions, but then may start to fail catastrophically as they dry out. Wet, muddy Prusiks slip in the 1200-1400 lbf range while drier muddy Prusiks seem to fail near 2500 lbf, much like dry Prusiks on dry rope.

Are these devices inappropriate to use in muddy conditions? It depends on what you are looking for. Prusiks on dryish rope stripped the mantle near 2500 pounds, just like dry Prusiks on dry rope. Failure in this case was stripping of the sheath, not catastrophic Prusik failure as has usually been the case. This may be a result of the older rope used. Prusiks on wet, muddy rope slipped from 1200-1400 lbf, in some ways mimicking the performance of the MPD under ideal conditions. If you are counting on your Rescucender slipping to limit force, then don't get mud on your rope. If you want your Rescucender to grip extra tight, then mud is just fine, but at the price of stripping the sheath at a higher peak force. The MPD performs very well in muddy conditions but slips at a higher force than with clean dry rope. If your safety ratios depend in it slipping at a lower force, don't use it on muddy rope. If slipping at the higher force is OK, then it performs just fine.

This study has limitations. Mud is not uniform. What gets on your rope will vary from site to site. This study did not look at what might happen if there was grit involved which might add a destructive effect. For two of these series the hydration of the mud was not the same. It dried out quickly in our testing environment. We used two different MPDs instead of a single one which added a potential confound.

Were we do try this again we would do a few things differently. We would make much less mud; one or two pounds of clay dust would be sufficient. Instead of applying the mud the night before, we would apply fresh mud immediately before each test to ensure a more uniform hydration.